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Description

This invention relates to an atomiser for cl an-ing liquid and a method of using it whereby high impact (shear) forces are achieved using gas and liquid at low inlet pressures and flow rates that are accelerated to near sonic velocities to effectively clean surfaces.

High pressure spray cleaners are frequently used in the electronics and computer industries to obtain ultra clean surfaces. High pressure spray cleaners use high volumes (litres/minute) of liquid at pressures of from 1,000 to 8,000 psi (7×10^6 to 5.5×10^7 Pa). Use of these large volumes of liquid and high gas pressures results in high operating costs for equipment. Where toxic cleaning liquids or gases are used, there is potential danger to human safety and the environment in disposing of spent liquid and gas or in the event, for example, of rupture of storage tanks containing highly pressurized liquid or gas.

Devices have heretofore been proposed that use gas to atomize liquids. For example, U.S. -A- 2,912,064 discloses a device wherein air at a pressure of 5-15 psi (3.5×10^4 to 1×10^5 Pa) is mixed in a venturi throat with an aerosol lubricant of fog-like particles from an aerosol generator for reclassifying them into larger particles immediately prior to deposition with considerable force on a surface to be lubricated.

U.S. -A- 4,324,365 discloses an atomizer in which liquid is fed to a venturi chamber through a capillary tube. A gas is fed into the chamber and through an annular clearance defined between the outer surface of the tube and surrounding venturi throat. The tube outside diameter is specified as 70-75% of the diameter of the venturi throat to provide the venturi restriction clearance.

The invention seeks to provide an atomiser for spray cleaning using a relatively low flow rate and a relatively low pressure of the cleaning liquid.

DE-A-1 403 149 describes an atomiser for a fluid which comprises an inlet chamber for receiving a supply of pressurised gas, a bore communicating with the inlet chamber and a tube for receiving a supply of pressurised fluid. The tube is coaxial with the bore and there is a radial clearance between the tube and the bore so that a venturi throat is defined therebetween. The bore extends beyond the outlet end of the tube. The dimensions of the various components are not given in this patent specification.

The object of the present invention is to provide an improved atomiser for a cleaning liquid.

The the invention relates to an atomiser for a cleaning fluid which comprises an inlet chamber for receiving a supply of pressurized gas, a bore communicating with the inlet chamber, and a tube for receiving a supply of pressurized cleaning liquid, the tube being coaxial with the bor and there being a radial clearance between the tube and the bore so that a venturi throat is defined therebetween, and the bore extending beyond the outlet end of the tube.

According to the invention the atomiser is characterised in that the dimensions of the components of the atomiser are such that

(a) the diameter of the inlet chamber at the inlet end of the bore is at least 2.5 times the diameter of the bore,

(b) the bore has a length at least five times that of its diameter, and

(c) the distance (G) the bore extends beyond the outlet end of the tube is related to the diameter (D) of the bore and an angle a which is one-half ~~the~~ spray angle of the cleaning liquid as it leaves the tube (11) in accordance with the expression:

$$\frac{D}{G} \geq 2 \tan a$$

Preferably, the flow rate of the liquid is less than 1/1000 that of the gas and less than about 30 millilitres/minute. The pressure of the liquid is preferably between about 20 and 50 psi (1.4×10^5 and 3.3×10^5 Pa) and that of the gas is preferably between 15 and 100 psi (1×10^5 and 7×10^5 Pa). This low flow rate-low pressure system efficiently cleans surfaces with minimal effluent and is safer and cheaper to operate than high rate-high pressure spray cleaners. Effluent disposition cost and environmental impact are minimised.

How the invention can be carried out will now be described by way of example, with reference to the accompanying drawing which is a schematic cross-section of an atomiser device embodying the invention.

As illustrated in the drawing, an atomiser embodying the invention comprises a housing 10 supporting a liquid injection tube 11, such as a syringe-type needle, and a gas acceleration tube 12. Tube 11 has a portion 11a that is coaxially aligned with, and projects with radial clearance into the entry end of, tube 12 to define a venturi throat 13.

As illustrated, tube 12 has an exit portion 12a that projects externally of housing 10 into proximity with a work surface 14 that is to be cleaned. Adjacent the entry end of tube 12 is an inlet chamber 15 to which a dry pressurised gas, such as air, is supplied from a suitable source (not shown). Air from this source could be emitted via an impeller (not shown) to circulate and facilitate compaction of the air into a cylindrical configuration. Cleaning liquid is injected into tube 11 from a separate source (also not shown).

By arranging the ratio of the gas to liquid volumetric flow rate to be between 1,000 and 1,000,000, and the ratio of the length L of acceleration tube 12 to its inner diameter D to be greater than 5, a preferred jet formation, liquid droplet and gas velocities and liquid drop size distribution is obtained.

The distance G between the exit end of injection tube 11 and the exit end of the acceleration tube 12 is preferably set to minimize liquid impact on the inner diameter D of the acceleration tube. To achieve this, D/G should be ≥ 2 tan a, where a equals one-half the liquid spray angle of the liquid as it leaves tube 11. Further optimisation toward eliminating, or at least minimising, liquid impact on the inner walls of acceleration tube 12 can be achieved by adjusting the flow rates QG and QL of the gas and liquid and the inner diameter F of liquid injection tube 11 with respect to the inner diameter D of the acceleration tube.

W is the distance from the end of acceleration tube 12 to work surface 14. The ratio of W to the inner diameter D of tube 12 should be less than 4 in order to prevent, or at least minimize, jet entrainment and therefore a deceleration due to mixing. The ratio of the effective inner diameter C of air inlet chamber 15 to the inner diameter D of acceleration tube 12 should be at least 2.5 in order to achieve high (sonic or near sonic) air velocities in the acceleration tube to impart high acceleration to the liquid droplets formed in the manner now to be described.

In operation, cleaning fluid is injected via tube 11 into venturi throat 13, at a pressure of about 20-50 psi (1.4 x 10^5 to 3.5 x 10^5 Pa) and a flow rate of 6-30 ml/min. Concurrently, dry gas is supplied to throat 13 via inlet chamber 15, preferably at a pressure of about 15-100 psi (1 x 10^5 to 7 x 10^5 Pa) and at a flow rate of less than 5 cu.ft./min. (0.14m^3 per minute). When the air enters acceleration tube 12, it is accelerated substantially to sonic velocity. This high velocity air mixes with the water within tube 12 and breaks up the liquid into small droplets (i.e., atomises it); these liquid droplets are accelerated by the high velocity air to a velocity at least equal to half that of the air. When these high velocity liquid droplets strike work surface 14, they create shear stress at that surface. The shear stress thus developed will remove contamination or other matter from surface 14 and carry it away from the area of contact.

To maximise the final velocity of the droplets, tube portions 11a and 12a should be vertically disposed above the work surface 14 so there will be no drooping of the droplet stream due to gravity.

At the time of impact with surface 14, air velocities in excess of 300 metres/sec and of the liquid droplets in excess of 150 metres/sec were achieved using a device embodying the invention and operated in the above manner. The cleaning liquid was deionised water at an inlet pressure of 30-35 psi (2.1 x 10^5 to 2.5 x 10^5 Pa) and flow rate of 6-10 ml/min; and the gas was dry air at an inlet pressure of 60 psi (4.2 x 10^5 Pa) and flow rate of 1.65 cu.ft./min. (0.046m^3 per minute). The dimensions of the device were as follows:

QG/QL	= 5600
L/D	= 7.4
D/G	= .21 with G = 10.8 mm
C/D	= 2.7
W	= about 2 mm
W/D	= .76
a	= about 6°

Although in the actual test and application just described, the cleaning liquid used was deionized water, toxic solvents, such as carbon tetrachloride, may be used if desired. In such event, environmental impact is significantly reduced due to low flow rate and hence low volume of effluent required to be removed, and the low pressures of the liquid and gas.

It will be understood that, if preferred, housing 10 may be extended toward work surface 14 such that the outer tube portion 12a may be eliminated and tube 12 replaced with merely a bore. If desired, the atomiser can be used to dry the surface with high velocity dry air after cleaning, by shutting off the supply of liquid to tube 11.

Alternatively, the air chamber inlet may be coaxially aligned with tube 12 and the injection tube may enter laterally, so long as the portion 11a is coaxially aligned with tube 12.

Claims

1. An atomiser for a cleaning liquid comprising an inlet chamber (15) for receiving a supply of pressurised gas, a bore (12) communicating with the inlet chamber and a tube (11) for receiving a supply of pressurised cleaning liquid, the tube being coaxial with the bore and there being a radial clearance between the tube and the bore so that a venturi throat is defined therebetween, and the bore extending beyond the outlet end of the tube (12a),

   characterised in that

   the dimensions of the components of the atomiser are such that

   (a) the diameter of the inlet chamber at the inlet end of the bore is at least 2.5 times the diameter of the bore,
   (b) the bore has a length at least five times

that of its diameter, and

(c) the distance (G) the bore extends beyond the outlet end of the tube is related to the diameter (D) of the bore and an angle a which is one-half the spray angle of the cleaning liquid as it leaves the tube (11) in accordance with the expression:

$\frac{D}{G} \geqq 2 \tan a$

2. A method of cleaning a surface of a workpiece using an atomiser as claimed in claim 1, in which the cleaning liquid is supplied at a flow rate less than 1/1000th of the flow rate of the gas.

3. A method as claimed in claim 2, in which the cleaning liquid is supplied at a pressure between 1.4 x 10^5 and 3.5 x 10^5 Pa (20 and 50 psi) and the gas is supplied at a pressure between 1 x 10^5 and 7 x 10^5 Pa (15 and 100 psi).

4. A method as claimed in claim 3, in which the cleaning liquid is supplied at a flow rate of less than 30 millilitres/minute and the gas is supplied at a flow rate of less than 0.14 m^3 per minute (5 cubic feet/minute).

5. A method as claimed in claim 4, in which the cleaning liquid is supplied at a flow rate of 6 to 30 ml/min.

6. A method as claimed in any of claims 2 to 5, in which the outlet of the atomiser is disposed at a distance from the workpiece which is less than four times the diameter of the bore.

Revendications

1. Pulvérisateur pour liquide de nettoyage comprenant une chambre d'entrée (15) pour recevoir une alimentation de gaz sous pression, un conduit (12) qui communique avec la chambre d'entrée, et un tube (11) pour recevoir une alimentation de liquide de nettoyage sous pression, le tube étant coaxial au conduit et un jeu radial étant prévu entre le tube et le conduit de sorte qu'un col de venturi est défini entre ces derniers, et le conduit s'étendant au-delà de l'extrémité de sortie du tube (12a), caractérisé en ce que les dimensions des composants du pulvérisateur sont telles que

(a) le diamètre de la chambre d'entrée, à l'extrémité d'entrée du conduit, est au moins 2,5 fois plus grand que le diamètre du conduit,

(b) le conduit a une longueur au moins 5 fois plus grande que son diamètre, et

(c) la distance (G) dont le conduit s'étend au-delà de l'extrémité de sortie du tube est liée au diamètre (D) du conduit et à un angle a qui est la moitié de l'angle de pulvérisation du liquide de nettoyage lorsqu'il sort du tube (11), conformément à l'expression

$\frac{D}{G} \geqq 2 \tan a$

2. Méthode de nettoyage d'une surface d'une pièce au moyen d'un pulvérisateur suivant la revendication 1, dans laquelle le liquide de nettoyage est fourni à un débit inférieur au millième du débit du gaz.

3. Méthode suivant la revendication 2, dans laquelle le liquide de nettoyage est fourni sous une pression comprise entre 1,4 x 10^5 et 3,5 x 10^5 Pa (20 et 50 psi) et le gaz est fourni sous une pression comprise entre 1 x 10^5 et 7 x 10^5 Pa (15 et 100 psi).

4. Méthode suivant la revendication 3, dans laquelle le liquide de nettoyage est fourni à un débit inférieur à 30 millilitres/minute et le gaz est fourni à un débit inférieur à 0,14 m^3 par minute (5 pied cube/minute).

5. Méthode suivant la revendication 4, dans laquelle le liquide de nettoyage est fourni à un débit de 6 à 30 ml/min.

6. Méthode suivant l'une quelconque des revendications 2 à 5, dans laquelle la sortie du pulvérisateur est disposée à une distance de la pièce à nettoyer qui est inférieure à quatre fois le diamètre du conduit.

Patentansprüche

1. Zerstäuber für eine Reinigungsflüssigkeit, der aufweist: eine Einlaßkammer (15) zum Aufnehmen eines Anschlusses eines unter Druck gesetzten Gases, eine Bohrung (12), die mit der Einlaßkammer und einer Röhre (11) zum Aufnehmen eines Anschlusses einer unter Druck gesetzten Reinigungsflüssigkeit kommuniziert, wobei die Röhre koaxial mit der Bohrung ist und ein radialer Zwischenraum zwischen der Röhre und der Bohrung so vorhanden ist, daß ein Venturi-Durchlaß dazwischen definiert ist und sich die Bohrung über das Auslaßende der Röhre (12a) erstreckt,

dadurch gekennzeichnet, daß

die Abmessungen der Bestandteile des Zerstäubers solche sind, daß

a) der Durchmesser der Einlaßkammer bei dem Einlaßende der Bohrung zumindest das 2,5-fache des Durchmessers der Bohrung ist,
b) die Bohrung eine Länge aufweist, die zumindest das Fünffache jener seines Durchmessers ist und
c) der Abstand (G), um welchen sich die Bohrung über das Ausgangsende der Röhre erstreckt mit dem Durchmesser (D) der Bohrung und einem Winkel a, welcher der halbe Sprühwinkel der Reinigungsflüssigkeit ist, wenn sie die Röhre (11) verläßt, entsprechend dem folgenden Ausdruck in Beziehung stellen:

$\frac{D}{G} \geqq 2 \tan a$

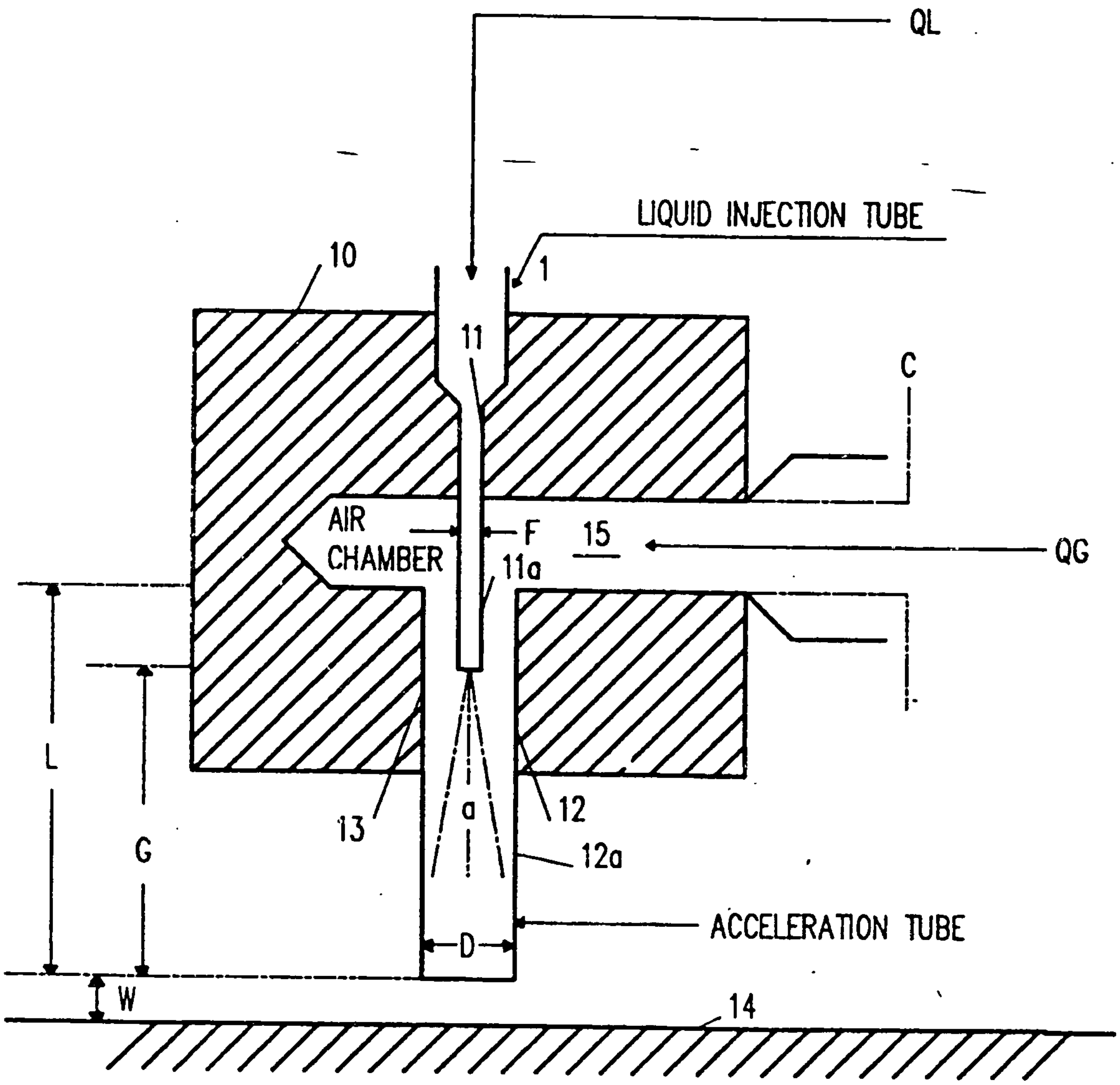
2. Verfahren zum Reinigen einer Oberfläche eines Werkstückes unter Verwendung eines Zerstäubers nach Anspruch 1, bei welchem die Reinigungsflüssigkeit bei einer Flußrate, die weniger als 1/1000-tel der Flußrate des Gases beträgt, zugeführt wird.

3. Verfahren nach Anspruch 2, bei welchem die Reinigungsflüssigkeit bei einem Druck zwischen $1{,}4.10^5$ und $3{,}5.10^5$ Pa (20 und 50 psi) zugeführt wird und das Gas bei einem Druck zwischen 1.10^5 und 7.10^5 Pa (15 und 100psi) zugeführt wird.

4. Verfahren nach Anspruch 3, bei welchem die Reinigungsflüssigkeit bei einer Flußrate von weniger als 30 Milliliter/Minute zugeführt wird und das Gas bei einer Flußrate von weniger als 0,14 m^3 pro Minute (5 Kubikfluß/Minute) zugeführt wird.

5. Verfahren nach Anspruch 4, bei welchem die Reinigungsflüssigkeit bei einer Flußrate von 6 bis 30 ml/min zugeführt wird.

6. Verfahren nach irgendeinem der Ansprüche 2 bis 5, bei welchem der Auslaß des Zerstäubers in einem Abstand von dem Werkstück angeordnet ist, der kleiner ist als das Vierfache des Durchmessers der Bohrung.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